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Preservation of Nonpaper Materials

Present and Future Research and Development in the Preservation of Film, Sound Recordings, Tapes, Computer Records, and Other Nonpaper Materials

When asked earlier this year by Erik Barnouw, the man who was originally to have given this paper, if I would allow my name to be suggested as a possible alternate since he would be unable to be here, I said yes. After spending some six months of work and thought on the subject, I fear that if I were asked the same question today that my answer would be a polite, but firm, no. The reason for my change of attitude is not that I feel the topic is unworthy. To the contrary, I feel it is of major importance to all libraries and archives of which I am aware. Nor is my present feeling on the subject due to an unwillingness to be involved in the work, since it is a substantial part of my present position, and is one of the aspects of the job which I find both particularly enjoyable and rewarding. Rather, my reservations on the topic are due to the especially broad scope of my topic and the time limitations which have had to be imposed on delivery of this paper. To give a reasonably thorough report on the present research and development of the preservation of any single format with which we as librarians must work would barely be possible in this one session. To broaden the scope to anticipate future research and development severely compounds the assignment. To do so for all nonpaper materials is truly impossible.

To compound my reservation I looked at the schedule and agenda of the institute. Of the twelve papers to be given, only this one specifically deals with nonpaper materials. Before allowing myself to become even more paranoid, I stopped and reviewed the position that nonpaper materials actually hold in libraries and to realize just how long they have been there. Until the last decade of the nineteenth century the only nonpaper in virtually all libraries was that associated with books or as furnishing for a library: the wood, leather, and metal of bindings; animal skins used before or as a substitute for paper; the wax used in seals and in color pigments; marble in statuary; etc. In fact, it was not until 1945 or later that most commonly accepted nonpaper formats were considered anything other than throwaways allowed into the library world in the United States. Also, I had to remind myself that I, too, am a paper based, book trained musicologist and librarian and that I held to that training and bias until taking a position in 1966 as sound recordings' librarian at the Sibley Musical Library of the Eastman School of Music.

Nonpaper materials are still considered by many—some might say most—of my traditionally trained colleagues as "nonlibrary" materials. Until very recent years the Oral History Project of Columbia University, the prototype for many such programs in this country, used sound recordings only as a means to simplify the collection of data. These recordings were then transcribed and collected into typescripts, whereupon the sound recordings were either erased to be used for another project or were destroyed.

Until 1877, civilization did not have the ability to record and playback sound. The camera was not invented until 1840. Though sound recordings were present in libraries as early as the turn of this century, it was not until 1958 that a generally accessible archival collection of sound recordings was established in a U.S. library. (Note: There were classroom collections in colleges and universities, as well as a fairly extensive collection of commercial classical music recordings and field recordings of ethnic materials available at the Library of Congress, but access to them generally required either special affiliation or advance notification of interest and special arrangements for playback.) Even though moving pictures were accepted as copyrightable items as early as 1897, they could come in only as "paper prints" (or photographs) and not as film. The Museum of Modern Art (MOMA), New York, established its film library in 1935, proclaiming motion pictures as worthy of research and scholarship, though primarily for their content as "art." As an archival medium, the motion picture was not generally accepted and collected until after World War II. Prints and photographs fared little better, even though there was an established collection at the Library of Congress as early as 1897. With the exception of a few areas, like census records, public opinion surveys, and bibliographic data, the collecting and storing of computer records as primary research data is still in its infancy.

As late as 1950, nonpaper materials—pictures, audio, machine data—represented less that 10 percent of the 28,691,350 items in the total collections of the Library of Congress. By 1980 this had grown to more than 20 percent of a collection of 76,945,360 items. Thus, during an acknowledged period of information explosion—a phrase generally used by librarians to mean an increase of paper based materials—the nonpaper collections of the national library dramatically increased by a factor of 5.4 while paper collections were increasing by a factor of 2.4; put another way, nonpaper materials increased by twice as much as paper materials during this vital period for libraries. Preliminary information from a broad range of libraries indicated that they, too, have experienced similar collection growth during this period.

The assigned title for this paper specified the media to be covered as film, sound recordings, tapes, computer records, and, in the event that something has been left out, other nonpaper materials. My approach will be slightly different, grouping the media as pictures (moving and still, regardless of their form or base material), audio, machine data, and a broad, miscellaneous "other." This "other" category will include materials that I assume generally would be included in the consideration of the preservation of unusual paper objects—maps, for example—or types of materials that would more properly belong in a museum preservation course: musical instruments, furniture, carpets, paintings. As much as I feel it desirable to include them in this paper, time does not allow me to discuss the preservation of these materials, nonpaper though they may be. However, any library which accepts these types of materials, whether to furnish a rare book room, to sponsor a series of musical concerts on their own instruments, or simply to keep a patron happy, has an obligation to see to their proper preservation.

My coverage of nonpaper media, with one exception, will be directly proportionate to my understanding of the likelihood of finding that format in a library collection. The exception will be for that substance whose deterioration might have a catastrophic effect upon virtually all other materials, paper and nonpaper alike, which are held in libraries: cellulose nitrate based film.

I will attempt to give some realistic idea of the component parts of the general media listed above, review the principal preservation problems which they currently face, and cite the storage conditions and preservation procedures recommended today. If there is a particular publication which has been tried and proved generally reliable, I will cite it. Because the container and/or label is of such significance for many nonpaper objects, and because it frequently is an inseparable part of the item, I will occasionally consider its preservation properties as well. Finally, I will review the more promising current research and development related to the preservation of nonpaper materials and share some speculations about the future prospects for storage and preservation both of original materials and the data they contain.

Picture materials can be grouped into motion pictures, microforms, stills, and video recordings. Motion pictures can, in turn, be subgrouped into film widths, such as the standard 8, 16, 35, and 70mm widths; positives and negatives; fine grain masters; separate picture and sound track and composite picture and track; black and white and/or color; carried in strips, open reels, cassettes, and cartridges. Motion pictures are most frequently encountered which have a base of either cellulose acetate (hereafter called acetate), polymers of the polyester type, with polyethylene terephthalate (hereafter called Estar) being the more common of the polymer group, or cellulose nitrate (hereafter called nitrate). A gelatin suspended emulsion layer, for black and white film consisting primarily of either diazo or light sensitive silver salts, known commonly as silver halides, or for color film consisting of several emulsion layers, is held on the base by a thin adhesive layer.

Microforms are most commonly found in 16 and 35mm, as microfiche or in reels, cassettes, or cartridges. They are also available in black and white and also color, although color microfilm is comparatively uncommon due to cost and color instability. They are made of materials similar to those of motion pictures and in the same wide variety of generations and formats.

Stills are similar to the two formats just described, but while negatives are on a transparent film or glass base, positives are most likely on paper. The image may be in the form of a print or intended for projection and magnification as with motion pictures and microforms. Also in existence, but not included in this paper, are such older photographic techniques as daguerreotypes, tintypes, ambrotypes, collodion-coated glass plates, and albumenized paper.

The last of the genre "pictures" to be considered is video recordings, the newest of this family and the most varied. The fixation of a television program may have the properties of motion picture film, as in a kinescope; it may be a magnetic image on tape or disc; or it may be a signal stored on a video disc. Digital versus analog signals are the latest competitors in the media contest.

The principal thing we must know about digital and analog is that for every generation it is removed from the original recorded event, an analog signal loses information. By the time a film is copied six generations away from its original source, the human eye can easily see visible deterioration of the quality of the image and of the information being presented. There is no generation loss in reproducing a digital signal, regardless of the number of generations one may get from the source. A one-on-one comparison of the original and a copy 100 generations away should present no change in quality or quantity of digitally transmitted information.

There are presently three types of video disc. As with most other nonpaper formats, picture and nonpicture alike, the player built for one type of system will probably not play the discs from the other two. If we were public consumers we could wait to get the machine that finally, if ever, wins out. Unfortunately, libraries must collect and make available materials wanted and needed for research. As with other nonpaper materials, if the data is important enough, this usually means acquiring the material in the form then available, and acquiring and maintaining the necessary equipment to play it.

The first of the three disc systems on the market was LaserVision, originally made only by Magnavox, but now available as well from U.S. Pioneer, and, in industrial versions, from Sony and MCA DiscoVision. It is the one least like the conventional phonograph, since its 12-inch discs are read by lasers, not stylii, so there is no physical contact to wear out the discs. The recording is under the disc's transparent surface and the laser reads the bottom of the disc from the inside out. This system uses a Constant Angular Velocity (CAV), which is to say that the longer groove at the outside edge of the disc takes no longer to play than does the shorter groove at the inside margin of the disc. This allows for such "extras" as perfect still frame, slow motion, fast motion, and direct access to any individual frame. Unfortunately, it also means that the playing time of the disc is roughly 30 minutes per side as opposed to the approximately 60 minutes per side of the Constant Linear Velocity (CLV) discs. Or, it may hold roughly 54,000 still frames.

The RCA Selectavision, introduced in the spring of 1981 using CLV, is more like the conventional audio phonograph. Its sylus senses variations in electrical capacitance as it rides over microscopic pits in the bottom of the disc's grooves. For protection against dust and scratches, the Selectavision disc is covered by a rigid plastic sleeve that stays on until the disc is in the player. This system has no true still frame, slow motion, or fast motion. Its sound and picture quality are presently a bit lower than that of LaserVision, and the first few players on the market do not have the stereo sound capability of LaserVision. The Selectavision mode disc (also known as Capacitance Electronic Disc, or CED) has been adopted by Zenith, Hitachi, Toshiba, Sears, Sanyo, Ward, and Radio Shack.

I have not yet seen the third system, although it was to have appeared sometime in the fall of 1981. Called VHD, or Video High Density, it reportedly will be manufactured by Panasonic, General Electric, JVC, Quasar, Sharp, and Mitsubishi, and will require a similar protective jacket to the RCA Selectavision. Like LaserVision, it has no physical groove walls. Instead, its track is defined by tiny rows of recorded guide pulses, so it is being listed as offering the same extra features as LaserVision.

There are two main types of videocassette formats, VHS and Beta. The chief differences are tape speed, cassette size, and the path through which the tape is threaded inside the machine. Since VHS tapes are in slightly larger cassettes and run at slightly slower speeds, their maximum playing time is a bit longer (six hours as opposed to Beta's five). Beta's simpler tape path makes such operations as shifting between play and fast forward quicker and more convenient.

In addition to these two video tape recorders utilizing cassettes, there are, also, open reel and cartridge fed recorders. Open reel, cartridge, or cassette differ primarily in the way the tape is held for playing, as well as in the manner the tape is fed through the machine. In addition, there are wide variations within virtually all three video tape formats in the width of the magnetic tape, coming as wide as two-inches, or as narrow as 1/4 inch.

For our preservation information purposes, the primary differences between video tape pictures and video disc pictures are:

1. the ability to record and play, or, as the industry calls it, to "write and read." The video disc systems now generally available only "read" what has already been "written." Magnetic tape, regardless of its packaging, has "write and read" capability; and
2. the LaserVision disc, and presumably the VHD system, offers the potential of not being damaged by the act of "reading," since the stylus does not come into contact with the encoded information. All other systems, whether video disc or tape, as well as all the parts of the other members of the "Picture" family, require direct contact of equipment and the carrier in order to make the data human readable and retrievable. This, obviously, has far reaching repercussions for preservation of all data.

Audio materials are grouped into discs, cylinders, mechanical devices, film, and wire and tape.

The disc group varies in size from approximately one-inch to twenty inches or more in diameter, and from 1/64 of an inch to 1/4 or more of an inch in thickness. They have been made of hundreds of the solid substances presently known, including plastics, shellac, glass, wax, metal, rubber, tinfoil, wood, paper, and even chocolate candy. They also come in a combination of these: a core of metal, wood, glass, plaster of Paris, or paper, or a combination of these, and a playing surface of plastic, acetate, wax, or shellac. Their signal may be analog or digital, recorded either acoustically or electrically, using either a lateral or a vertical cutting and playback stylus. They play at speeds of less than 10 to greater than 100 revolutions per minute (RPM). Their stylii have a tip radius from .0005 to 35 mils, with intended tracking weights of less than 0.25 of a gram to several or more pounds in a groove that varies from microgroove to standard/coarse goove widths, with all variations in between and beyond. The modern commercial "LP" disc is fairly standardized. This has not always been the case. If the manufacturer were using a different recording and playback signal and needed specific tracking, signal configuration and packaging to accomplish the desired end, the manufacturer created a new system—for example hill-and-dale and lateral grooves. Multi-channel sound was realized by using binaural, bilateral, encoded, and enhanced mono; or, to insure that the public used their discs, manufacturers did such things as putting a large square spindle on the record machine so that the buyer of the machine would have to buy records with a similarly shaped hole. Each of these variants, whether of size, speed, stylus size and pressure, type of recording, direction of tracking, et al., requires a specific, working machine for information retrieval. Just as with most other nonpaper formats, an attempt to play a disc on the wrong machine will result in varying degrees of damage to the information-carrying package.

Cylinders are the earliest form of sound recordings. They were the only successful form of recording sound for the first fifteen or so years of the history of the phonograph, and they were an accepted form—in some areas they were the preferred form—until well into this century. Though most people today would recognize almost every other form of sound carrier covered here today, few would make the connection between cylinders and sound.

Cylinders come in a range of sizes almost as varied as those just mentioned for discs. Their recording signal and mode are, however, generally limited to hill-and-dale and mono, although the number of grooves varies.

The mechanical, or music box devices, are far too numerous to mention in any depth here. Their triggering devices were usually a disc, barrel, or strip of wood or paper with either indentions, protrusions, or simple cutouts intended to trigger an action: the plucking of a series of tuned springs, the opening of a pipe, the release of a hammer, the opening of a wind channel, etc. The instruments which were so activated were as varied as the modern player piano, a music box, a mechanically played violin, a church organ, or an entire orchestra of string, wind and percussion instruments.

Film audio materials utilize the same base materials as those found in motion picture film: acetate, nitrate, and polyesters, with all of the inherent problems of each. The recording signal can be either in a cut groove or a strip of magnetic tape applied to the film. In addition, there is optical sound: a photographic line of varying width and frequency in transparent film. When in a cut groove, it carries the same type of hill-and-dale and/or lateral cut signal that one finds in the grooves of discs or cylinders. When in a strip of magnetic tape embedded in the film, the signal has the same possibilities as will be shortly listed for audio magnetic tape. The base material, regardless of its makeup, is generally 35mm wide.

Wire and tape audio recordings are grouped together here not because of their base materials, for they are usually quite different, but because of their similarity of signal. They both depend, as does videotape, upon a magnetic signal held in wire, in the wire itself, and in tape, in magnetic particles which have been dispersed in a resin binder. The packaging of both, as with videotape, may be either an open reel, a cartridge, or a cassette.

The wire varies in diameter from 0.7 to 1.2 mils and may be made of virtually any metal wire capable of holding a magnetic charge. Usually, however, it was made of either stainless steel or carbon steel.

Magnetic tape varies from 1/8 inch to 2 inches or more in width and 0.25 to 1.5 mils or more in thickness and has an acceptable playing speed, depending upon the signal to be placed on the tape and the desired level of response which will be minimally acceptable, from 15/16 ips to 60 ips or higher. Magnetic tapes are made on a base material, now usually of polyester, but originally on metal bands and paper and acetate strips. The paper, acetate, or polyester base material is covered in a gelatin which carries the resin binder loaded with magnetizable particles and, hence, the potential magnetic signal. The coating, or gelatin, is held in place by an adhesive layer, or is bonded to and is a part of the base. Both wire and tape can carry either analog or digital signals.

Other than base material, the principal difference in wire and tape is the number of tracks or bands of sound that each can potentially carry. Wire is limited to a single signal. Tape can carry an infinite number of signals depending upon the width of the tape and the size of the tracks thereon. It is not unusual for a modern magnetic tape to carry up to sixty-four different signals. For commercially available audio tape recordings the number is generally limited to a maximum of either four or eight such bands.

An additional difference is the method in which loose ends of each are connected to like materials. To splice a tape, one can either use splicing tape, a hot splice, or an ultrasonic splice. To "splice" wire one simply ties the two desired ends together in a small, tight knot.

Computer records have been stored in magnetic tapes, discs, punched paper cards, cylinders, crystals, and microforms. At present the most common format is magnetic tape utilizing a digital signal. Punched cards appear to be being phased out and the possibilities of crystal storage are just beginning to be realized. Occasionally one sees or becomes aware of analog signal recordings, usually on magnetic tape and used for backup and preservation purposes.

The worst disaster for most nonpaper materials is fire which is the disaster most likely to destroy virtually all possibilities of salvage, since so many of the base materials of modern nonpaper records are petrochemical products. This, of course, is true for virtually all library materials. Yet the greatest potential catastrophic degradation for any likely library item, and the format with the single most susceptibility to heat, much less to fire itself, is cellulose nitrate based film materials. Temperatures of only slightly over 100°F are sufficient to cause nitrate based film, with no visible signs of deterioration, to self ignite. Once ignited it burns at about 15 times the speed of wood, and once ignited it cannot be smothered, since it carries within its chemical makeup enough oxygen to feed its own combustion.

You may well ask how many of us have, or will ever have, nitrate based films in our collections? And if the number is as small as you are correctly thinking it is, then why waste time with this topic? Following a very unfortunate incident at the National Archives' remote nitrate film vaults outside Washington, D.C., in 1978, the Library of Congress became even more acutely aware of the potential disaster of having nitrate in other than a specifically designed and maintained film vault. The National Library was already aware that it had some 90,000+ cans of nitrate based motion picture film which had been maintained in separate, National Fire Protection Association (NFPA) approved vaults. The Library staff had pulled a large quantity of nitrate based still film and stored it under similar conditions. On closer inspection, staff found additional still film, but were confident that there was no nitrate motion picture film in the general film collections. In September 1981, the staff became aware of nitrate in a collection of materials which a very knowledgeable donor had told them held no nitrate, and which had previously been spot-checked to assure all concerned that such was the case. The collection had been placed in a remote area where large parts of the Library's general collection are held. It had been there for several years as specific preselected parts of it were brought out and integrated into the cataloged collection. Then, during September, the Library of Congress staff became aware that one of the reels being processed was nitrate. The entire collection was then inspected and it was discovered that there were an additional ten reels of nitrate based film in the 1200 or so in the collection. Your comment might logically be: "So what? It was only eleven reels of film out of the approximately 250,000 reels of safety film which LC holds." Eleven reels of 35mm film would weigh an average of fifty pounds. A single pound of burning nitrate based film gives off four to five cubic feet of such gases as nitric oxide, nitrogen dioxide and tetroxide, carbon monoxide, and carbon dioxide. Once burning, it cannot be extinguished by normal fire fighting techniques. The only reasonable hope is to contain the fire while keeping the temperature of other nearby items below their flash point. The usual means of doing this, and virtually the only one which seems to work consistently, is to pour large quantities of water on the fire and its area, thus introducing the second great enemy of paper and nonpaper library materials alike: water and flooding.

The Library of Congress currently has four 5 by 7 by 20 feet nitrate film vaults filled with flat nitrate based picture materials. The Smithsonian, also inspecting its immense collections following the 1978 NARS fire, has located enough nitrate based materials to fill almost three similarly sized vaults.

I urge you, if you have any film based materials possibly dating from the mid-1950s or before to contact Eastman Kodak and get their 1950s booklet on identifying, handling, inspecting, and storing nitrate film. The NFPA Code 40 deals with storage facilities for nitrate film and must be followed in every area of the United States of which I am aware. The odds are that you have none, but be sure. The greatest disaster attributed to a nitrate film fire occurred in May 1929, in a Cleveland, Ohio, hospital. The fire, started by a bare light bulb and faulty steam pipes in the X-ray film storage area, burned only some 4900 pounds of nitrate, or the equivalent of roughly 1000 cans of 35mm film, yet killed 125 persons. Virtually all of the fatalities were from the fumes and gases of the burning film, not from the heat of the fire. Reportedly, some of the deaths were as much as 48 hours later as apparent survivors were walking down the street or resting in their homes.

The picture materials most likely to be held by libraries are microfilm, both roll and fiche, 8 and 16mm projection prints of motion pictures, photographic prints, and a growing number of video cassettes.

The recommended storage of service copies of virtually all safety film calls for an area with filtered air, kept dark except when access is needed, with the temperature at 68° to 70°F, and with a relative humidity of 35 to 45 percent. All materials should be staged—allowed to come to ambient temperature and humidity before being taken from the storage area for use and brought gradually back to low temperature when being returned to storage—for at least twelve hours before being used. They should be on hubs, if appropriate, packaged and sealed into poly/foil bags or envelopes, and, for reels of motion picture film, shelved in nonrust, metal cans placed horizontally no more than three high on a shelf. Microforms and stills are usually filed in drawers rather than placed on shelves. All film products should be inspected regularly and, as appropriate to the format, rolled through no less than every three years.

The single largest problem which most libraries seem to have with all film based materials is surface scratches caused through normal use and handling. Of course, more careful handling, better maintenance of the equipment, and more care in cleaning the film and equipment before every use will make a significant difference in this problem. However, a new product recently offered by 3M holds great promise in this area, especially for rare and irreplaceable materials and for heavily used materials. Called "Photogard," it has a very impressive track record to date. The following data has been furnished by 3M. A polymerized silicone, Photogard can be put onto basically any processed photographic material, including glass. Magnetic tapes and optical video discs are presently being tested. It has potential use in the graphic arts, with X-ray and phosphorous screens, in photo finishing, and in all micrographic and motion picture applications. The 3M company does not recommend it for nitrate based film materials because of the use of heat in the application. Coated materials are:

1. *Highly resistant to abrasion.* In the Gardner Falling Sand Abrasion Test there is a 70 percent haze on uncoated film materials, and an 11 percent haze on like coated materials. On coated glass, the haze level drops to 10 percent. Photogard is approximately eleven times less abrasive than polyester.
2. *Highly antistatic.* The "half life" of an electrical charge at 50 percent relative humidity on Photogarded polyester film is 0.1 of one second. Uncoated, the "half life" of an electrical charge under the same conditions is 2000 seconds.
3. *Highly solvent resistant.* Coated film was virtually unchanged by chemicals that destroyed uncoated film.
4. *Easily cleanable.* Pencil, grease, oil, et al., wipe off. Cleaners may be either virtually any cleaning chemical, ultrasonic cleaners, or combinations of the two, with the major exception that all cleaners and machines should be free of wax.
5. *Virtually antibacterial.* Properly precleaned, coated film will support few if any bacteria.
6. *More resistant to ultraviolet (u/v) light fade.* There is a u/v light screen built into the coating, resulting in a decrease in u/v light fade by a factor of 4.
7. *More resistant to darkroom storage fade.* There is a 50 percent reduction in darkroom fade.

Photogard transmits 97 percent of visible light. The very smooth surface obtained by coating film reduces surface light scatter and greatly improves the legibility of a reel of microfilm which the Library of Congress had assumed to be virtually unusable. Obviously, the coating will make no major improvement on scratches which penetrate the emulsion. One other example of the usefulness of Photogard on heavily used film is that from the New York State Museum in Albany, New York. They showed the film *Logging* 8400 times over twenty-five weeks of an exhibit. Their films normally last a very impressive 2016 plays over the six weeks of a scheduled exhibit. After over four times as many showings, the Photogard coated film was still considered to be in an acceptable condition by museum personnel.

The principal negative result of the 3M tests is that there are some increased problems in cold splicing of coated film, but splicing can readily be accomplished by the use of available products and techniques. There is no particular problem with hot or ultrasonic splices.

In the matter of color fading of motion picture film images, Kodak has published its findings on color stability. Using short term tests at high temperatures to predict the density changes expected, they tell us that materials stored at room temperature (24°C/75°F) or lower, with dark keeping storage conditions at 40 percent relative humidity for all colors, have an acceptable density of 0.8 or better for fifteen to twenty years. By lowering the temperature to 16°C/60°F, we can expect 0.8 density or better for fifty or so years; and by going to -18°C/0°F, we go to upward of 1000 years of 0.8 density or better. By lowering the relative humidity to 15 percent we double the predicted dark storage capability by a factor of two. Specified data on particular motion picture products is available from Kodak, Dept. 620DS, Rochester, New York 14650, as is the data from which I took the above statistics.

There is one major problem with the Kodak data: there is presently available little information on the effect of temperature and relative humidity cycling on film when taking it from darkened, controlled atmosphere storage to a projector or printer and returning it to the cold vault. Kodak, of course, recommends the staging of materials coming and going from the cold vaults, but there appears to be little documented information on long term effects of repeated cyclings.

An additional problem in the preservation of film is the separation of the emulsion from the base material. The recommended, and apparently successful, solution to this problem is to maintain humidity and temperature as constantly as possible. If there must be a change in either or both of these vital elements of preservation they should come as slowly as possible, avoiding the sudden changes which take place when adequate staging is not practiced.

The recommended storage for all magnetic tape, regardless of the signal which it carries, its thickness, its width, or its packaging, is:

1. Where possible, use only reel-to-reel tape, on the largest possible unslotted hubs made of metal whose flanges are immediately replaced if they are deformed or out of plane.
2. Package reels in sealed metal cans or sealed boxes of a material such as polyethylene/cardboard/foil/polyethylene laminate. The boxes should be stacked on edge in the shelves. Tape should not be packaged until it is in equilibrium with the stacks.
3. Stack temperature should be maintained at 65° to 68°F and 40 percent plus or minus 5 percent relative humidity (RH) for often used recordings while storage in 50°F at the same relative humidity is recommended for seldom used and particularly valuable recordings.
4. Playback and packaging rooms should be maintained dust free and at the same 68°F/40 percent RH as the stacks. Tapes exposed to other en-

vironments should be staged in the playback environment before playback.

5. Stray external magnetic fields should not be permitted in the stack, playback, and packaging environments. The maximum flux density should be 10 gauss.
6. Playback equipment should be maintained as recommended by the manufacturer, including cleaning, tape transport adjustment, and component demagnetization.
7. A rewind and inspection deck, separate from playback facilities, should be used for packaging and inspection. Winding tension for 1.5 mil tape should be a constant torque of 3-5 ounces at the hub of a 10-inch reel.
8. The best tape presently available for storage purposes appears to be 1.5 mil Mylar base.
9. Tape should be recorded at a maximum level below 2 percent harmonic distortion (4db below normal recording level is usually satisfactory). The first and last fifteen feet of the tape should not be used for program recording, but should have a burst of 10 mil wavelength (approximately 750 cps at 7.5 ips) signal at maximum recording level preceded and followed by several layers of blank tape for inspection purposes.
10. Tape should be aged in the packaging room for six months prior to recording. Recorded tape which has been exposed to other than the prescribed environment should be conditioned in the packaging room for six weeks prior to packaging.
11. Tape should be inspected once every two years, measured from time of last playback, and rewound so that the curvature of the base is opposite to the direction of the previous curvature. This inspection should consist of measurement of print through caused by the toneburst at the end of the tape and a spot check at the tape end next to the hub for coating adhesion or delamination. It need not include playback.
12. Storage shelves should be made of wood or a nonmagnetizable metal free from vibration and shock.

The principal problems associated with magnetic recordings are undesired erasing of the magnetic signal, separation of the emulsion from the base material, print through, and tape breakage. There is no new breakthrough for these problems of the scope and magnitude of the 3M Photogard for film-based materials; the only prevention for them is care in handling and following of the recommended storage and handling procedures given above. For unique or very valuable materials it is always wise to have backup copies stored separate from the service copies. This, of course, presents the problem of generation loss in analog copies. If a master and a service copy are to be maintained, the master should be the item closest to the original and should be used only to create new service copies.

Computer centers have a very desirable backup procedure which, if possible, is recommended for all other tape collections: data banks are backed-up daily, with the backup copy being kept for a specified, overlapping period of time with other such tape copies. Tapes which are kept on site are periodically transferred to a safe storage area for additional backup capability. Since most computer records are digital, there is no loss of information from generation to generation. Thus, at any given time, virtually all of the data bank is available on site, in a backup copy also on site, and in a safe storage area for added protection.

The most frequently encountered sound recordings are 33 1/3 and 45 rpm vinyl discs, 78 rpm shellac discs, and magnetic tapes. The recommended storage for magnetic tapes and their principal problems have just been covered above. The recommended storage criteria for discs are:

1. Store the cleaned disc recording in a sealed sleeve made of a laminate of polyethylene/paperboard/foil/polyethylene of acid free thirty-four point chipboard or better, soft aluminum foil of 0.0001 inch thickness, and polyethylene. The discs should not be packaged and sealed until they are in equilibrium with the intended storage area.
2. Stack temperature should be maintained at 70°F and 45 percent plus or minus 5 percent relative humidity for often used recordings or for service copies, and 50°F and the same relative humidity for seldom used recordings.
3. Playback and packaging room(s) should be maintained dust free and at the recommended conditions for often used recordings. Discs exposed to other environments should be conditioned in the playback area for twenty-four hours before playback and for an equal period in the storage area atmosphere before being returned to storage.
4. Store in a darkened room, where possible, but always away from sunlight and from artificial lighting of the shorter wavelengths.
5. Store all discs in the vertical position without pressure on the disc surface or the opportunity for off vertical attitude, using only clean, unabrasive surfaced packaging as suggested in number 1 above; do not permit sliding contact of disc surface with other surfaces.
6. Play the disc only with a stylus of proper size and weight for the particular disc.
7. If a disc is to receive heavy playing, particularly if it is unusual or unique, make a service copy and use the original as the archival master as above.

The principal problems of preservation associated with disc recordings are warpage, heavy groove wear, breaking and rim chips (particularly of 78 rpm discs and older 33 and 45 rpm discs), and distortion of the playback grooves by fungi. These are generally readily correctable by proper handling, cleaning, packaging, and storage. Probably the single greatest problem in the preservation of disc recordings is groove wear. This can be greatly reduced by proper maintenance of the playback equipment, regular inspection of the stylus condition and weight, and regular cleaning of the disc. In addition, there are a number of products on the market today which treat the playing surface to either harden it to reduce groove wear, reduce the static electricity on the surface of the disc and thus cut down dust attraction, or remove the built up dirt and dust prior to playing. In general, I am very leery of anything which is going onto the surface of the disc that will alter or coat it and which, in all probability, will have to be removed at some point in the future if the disc is to be preserved. One product, however, LAST, has received high praise from many of my colleagues. The Library of Congress is currently considering whether to use the product for its collections.

A major problem with disc sound recordings which is, fortunately, lacking for the generally collected nonpaper materials is the presence of a label, usually paper, affixed directly to the surface of the disc. The paper label, with its glue or heat-seal and inks, introduces an entirely new problem to the preservation of these materials: How does the preservation of paper materials affect the preservation of nonpaper? Most other nonpaper materials have something of this problem, for publishers are forced, for reasons of bibliographic control if nothing else, to put identifying and descriptive information on the item or its container. In most cases, only the disc recording has its label affixed directly to its surface. This, also, raises special problems when the item is being cleaned: will the binder dissolve in water; will the paper dissolve; are the inks and dyes water soluable; is the paper acidic; will it support the growth of fungi? In most cases, the answers to these questions seem to be in favor of preservation: the glues may dissolve, as will the inks, dyes, and paper, but they can be protected with a little care in the cleaning and handling process. The paper seems, generally, to be low in acidity and resistant to fungus growth.

Publications of general use which have been evaluated and are considered by most working in the field to be relatively dependable are comparatively few. They include:

Bertram, H. Neal, and Stafford, Michael K. "The Print-Through Phenomenon." *Journal of the Audio Engineering Society*, vol. 28, no. 10, Oct. 1980.

———. *Recording Media Archival Attributes (Magnetic)* (Contract No. F30602-78-C-0181 PR NO. 1-8-4008). Redwood City, Calif.: Ampex Corp. 1979 (2d printing 1980).

Cuddihy, Edward F. "Aging of Magnetic Recording Tape." *IEEE Transactions on Magnetics*, vol. MAG-16, no. 4, July 1980.

Eastman Kodak. *Preservation of Photographs*. Rochester, N.Y.: Eastman Kodak, 1979.

———. *Storage and Preservation of Motion Picture Film.* Rochester, N.Y.: Eastman Kodak, 1957 (out of print, but selected portions have been reprinted by Kodak).

———. *Storage and Preservation of Microfilm.* Rochester, N.Y.: Eastman Kodak, 1981.

Pickett, A.G., and Lemcoe, M.M. *Preservation and Storage of Sound Recordings.* Washington, D.C.: Library of Congress, 1959 (out of print, but LC has announced its intention to reprint).

At present, there seems to be an active interest in the preservation of nonpaper materials. In recent years this has not been the case. The last in-depth work on the preservation and storage of sound recordings, for example, was published in 1959 and has been out of print for the last ten years or so. Currently, work is being carried out or is being actively considered by Kodak, 3M, various governmental agencies and bodies, including the intelligence community, the National Bureau of Standards, the National Archives, and the Library of Congress, as well as professional organizations and associations, including the American Film Institute, the Association for Recorded Sound Collections, the Audio Engineering Society, the International Association of Sound Archives, the Music Library Association, the Society of Motion Picture Technicians and Engineers, and the University Film Association. Of particular interest is the National Bureau of Standards' recently announced five year study of archival stability of polyester film—chemical properties. On an international level, Unesco adopted recommendations for the safeguarding and preservation of moving images at its general conference in Belgrade, in October 1980. In addition, a number of private individuals are personally working on specialized projects, including Art Schifrin with audio cylinders and early movie sound tracks, Henry Wilhelm on color stability, and Steve Smolian with radio transcription materials.

An important event that is taking place today is the development of systems for the storage of digital signals on optical video discs. This is important not only for the preservation of nonpaper materials and artifacts, but for information in general. The life span of an article in an ideal environment is a property which is built into the article when it is manufactured. Proper care cannot extend this potential life, although it can prevent premature failure. The importance of the optical disc is that it permits the storage and retrieval of data without subjecting it to the physical stresses of most current storage and playback. The advantages of this system are those which were cited earlier in this paper when I addressed the LaserVision disc. The disc is read by lasers, thus there is no physical contact with the stored data to wear it out faster than its own built in properties dictate. It uses a Constant Angular Velocity (CAV), thus allowing for perfect still frame, fast forward, and fast backward searches, along with direct access to any single frame. It has the capability to store aural, visual, and machine data in a digital mode, thus preventing loss of data in the transfer from one generation to another.

There are still a number of problems to resolve. Just what is the potential life of the disc? How susceptible is it to fluctuations in heat and humidity? Will its clear surface scratch easily? Will it discolor with age, or from heat and/or humidity? Will the laminated "sandwich" which makes up the disc separate because of heat or other factors? In addition, the present state of video does not allow for direct retrieval of an image with enough clarity and definition for most motion picture researchers, much less for the specialist working with manuscripts, art or maps, to name but three fields dependent upon clarity and resolution of image. Also, the range and fidelity of colors possible with video have been attacked by those working in areas where color is of importance: maps, art, pictographs, etc. Nonetheless, this device seems to be the solution of most of the preservation problems which are faced by every other known library medium, paper and nonpaper alike. We look with great anticipation to the realization of the solution of these problems and want to believe those who tell us that we can have the requisite resolution and color while assuring us that the problems of storage and preservation are really not unsolvable.

We still have the materials we have inherited, however. The optical disc and its solutions, while promising for many lesser applications, cannot conserve those items we must retain in their original physical form. For those items, we must do everything possible to insure that the life span potential built into all the materials placed in our keeping is realized to its fullest possible extent. Otherwise, if ever a permanent preservation system is developed, we will have far less to preserve and share with the future than we received from the past.

The interrelationships between the general needs for space, shelving, storage, structural weight loads, temperature and relative humidity, packaging, and shielding for the varied materials being considered can best be seen in the accompanying table.

TABLE 1

GENERAL PHYSICAL NEEDS FOR MOST COMMON NONPAPER LIBRARY MATERIALS

Type	*Temperature (Fahrenheit)*	*Relative Humidity*	*Recommended Packaging*	*No. of Items/ Linear Ft. of Shelving*	*Weight of Average Item in Pounds*	*Weight/Linear Ft. of Shelving*
FILM						
MoPict* (safety based)						
16mm (1M)	70° ± 5°	40% ± 5%	film in poly/foil bags; heat sealed; film on hubs; nonrust metal cans; cans horizontal, maximum of 3 cans high	3.00	2.33	6.99
16mm (2M)	70° ± 5°	40% ± 5%		1.75	4.95	8.66
35mm (1M)	70° ± 5°	40% ± 5%		3.00	5.00	15.00
35mm (2M)	70° ± 5°	40% ± 5%		1.75	9.16	16.03
MoPict* (nitrate based)						
	50° ± 5°	40% ± 5%	for special vault construction see NFPA Code 40; film should be hand inspected every 6 months shelved in nonrust metal cans; cans horizontal, maximum 3 cans high	same as for similar formats, nonnitrate base		
Stills*	70° ± 5°	40% ± 5%	poly/foil sleeves; heat sealed; in drawers			
Micro*	70° ± 5°	40% ± 5%	poly/foil sleeves or bags (fiche/roll); heat sealed; rolls on reels; in acid containers			
Video**						
½″ Cass	65° ± 5°	40% ± 5%	tape in poly/foil bags; heat sealed; supported center hubs for reel tape; in low acid containers; vertical on shelf; nonmagnetic shelving		1.77	
¾″ Cass	65° ± 5°	40% ± 5%			1.71	
1″ Reel	65° ± 5°	40% ± 5%			5.00	
2″ Reel	65° ± 5°	40% ± 5%			17.50	

AUDIO**						
Discs						
LPs (10&12)	70° ± 5°	45% ± 5%	poly/foil sleeves; heat sealed;	66	0.51	33.66
45s	70° ± 5°	45% ± 5%	stiff outer sleeve of low acid	66	0.22	14.52
78s (10&12)	70° ± 5°	45% ± 5%	material; vertical on shelf;	66	0.60	39.60
16″ vinyl	70° ± 5°	45% ± 5%	full height/width dividers	66	0.60	39.60
16″ acetate	70° ± 5°	45% ± 5%	every 5 inches	66	0.90	59.40
Tape**						
Cass	65° ± 5°	40% ± 5%	in poly/foil bags/lined low		0.16	
Cart.	65° ± 5°	40% ± 5%	acid boxes; heat sealed;		0.30	
10″ Reel	65° ± 5°	40% ± 5%	supported center hubs for reel		1.77	
7″ Reel	65° ± 5°	40% ± 5%	tape; heavy, nonslotted hubs; vertical on nonmagnetic shelving; smaller items may be in drawers		0.73	
Cylinders	68° ± 5°	45% ± 5%	poly/foil lined low acid center supported stiff boxes; filed in drawers, 1 level deep; vertical position	11 per sq. ft.	0.27	4.32 per sq. ft.

MACHINE DATA

same as for mag materials

*For film based materials image stability (especially color images) Kodak recommends considerably lower temperature (O°F or lower, dependent upon acceptable level of image fade) and relative humidity of 15%.

**For audio and mag based video materials, approximately 50° ± 5°F is recommended for archival storage.

TABLE 1—*Continued*

Type	*Filtered Air*	*Shielding Recommended*	*Dark Storage*	*Staging if Stored in Lower than Work Area Temp/ Relative Humidity*	*Inspection/Rewind where Applicable*
FILM					
MoPict (safety based)					
16mm (1M)	Yes	U/V*; mag/RF** for	Yes	Yes	Every 3 years
16mm (2M)	Yes	mag strip sound	Yes	Yes	Every 3 years
35mm (1M)	Yes	mag strip sound	Yes	Yes	Every 3 years
35mm (2M)	Yes	mag strip sound	Yes	Yes	Every 3 years
MoPict (nitrate based)	Yes	U/V; heat	Yes	Yes	Every 6 months
Stills	Yes	U/V	Yes	Yes	Every 3 years
Micro	Yes	U/V	Yes	Yes	Every 3 years
Video	Yes	U/V; mag/RF non mag shelving	Yes	Yes	Every 2 years

AUDIO					
Discs					
LPs	Yes	U/V	Yes	Yes	No
45s	Yes	U/V	Yes	Yes	No
78s	Yes	U/V	Yes	Yes	No
16″ vinyl	Yes	U/V	Yes	Yes	No
16″ acetate	Yes	U/V	Yes	Yes	Every 12 months for loss of plasticizer
Cylinders	Yes	U/V	Yes	Yes	No
Tape	Yes	U/V; mag/RF; non mag shelving free from vibration	Yes	Yes	Every 2 years
MACHINE DATA same as for mag data					

*U/V—ultraviolet
**RF—radio frequency

DISCUSSION

William Aguilar (student, Graduate School of Library and Information Science, University of Illinois at Urbana-Champaign): Recently in a stereo review journal, I was reading about a new product by Sony Corporation. This product was a 35mm camera that was rather unique in that it did not use any film; instead it used some type of magnetic device. The image was played back on a television screen. I'd like to know if you could tell us anymore about this device and its impact on the microfilming industry.

Gerald Gibson: Though I have not seen the item to which you refer, the main impact would seem to be in the home photographic market. As I understand the product, it is not a 35mm image, nor even a photographic image. Rather it is a magnetic recording to be played back via a video system. With it comes all of the problems of resolution, of clarity, and of color which any other magnetic video system presents to its users. If you want a general image, or at least do not need one with greater resolution than your video screen furnishes, then you will probably be OK. If you wish detailed information or storage capability, this type of image gives you the same problems as other magnetic video signals. For example, the film I showed here today was first copied onto video cassette by the Library's video lab. Usually their work is quite good, so I do not think that was where the problem lay. In any event, the video cassette copy was unusable for public presentation. You could not see a useful picture unless you were close enough to touch the screen. It lacked the level of clarity that exists even with a poor 16mm copy. I do not think there is any serious consideration of the device you mention for use in preservation.